

ELECTRONIC FUNDAMENTALS



Service Practices 21:

CHECKING AND
SERVICING SWITCHES

Service Practices 22:

PHONO AND
RECORDER MOTORS



RCA INSTITUTES, INC.

A SERVICE OF RADIO CORPORATION OF AMERICA

New York,

N. Y.

ELECTRONIC FUNDAMENTALS

SERVICE PRACTICES '21

CHECKING AND SERVICING SWITCHES

- 21-1. Contact Methods
- 21-2. Kinds of Switches – Switch Action
- 21-3. Throws, Poles, and Basic Symbols
- 21-4. Some Simple Switching Circuits
- 21-5. Plugs, Jacks, and Jack Switches
- 21-6. Rotary Switches
- 21-7. Switch Wafers
- 21-8. More Switching Circuits
- 21-9. Power-Handling Ability
- 21-10. Switch Troubles – Maintenance
- 21-11. Analyzing a Switch Schematic and
Troubleshooting



RCA INSTITUTES, INC.
A SERVICE OF RADIO CORPORATION OF AMERICA
HOME STUDY SCHOOL
350 West 4th Street, New York 14, N. Y.

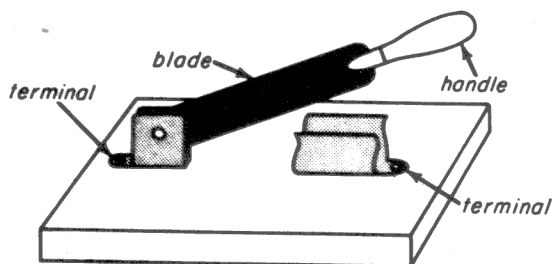
Service Practices 21

INTRODUCTION

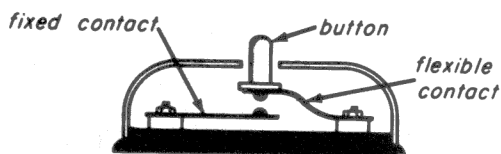
Switches control the flow of electricity. We use switches to light electric lamps, to ring bells, to turn on automobile ignition and lighting circuits, and to turn on our radio and television receivers. A switch is simply a convenient device for opening or closing an electric circuit. The wires in a circuit are brought up to two or more points, called the terminals of the switch, and these points are connected or disconnected by the operation of the switch.

21-1. CONTACT METHODS

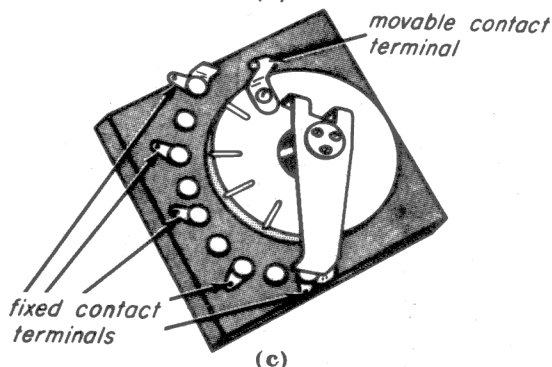
There are certain basic ways in which a switch contacts the circuit terminals that it



(a)



(b)



(c)

Fig. 21-1

is intended to connect and disconnect. Understanding the basic contact methods makes it much easier to understand switches. The typical radio or television switch makes use of one or more of three basic methods of making contact: knife contact, pressure contact, and wiping contact.

A *knife-contact* switch (Fig. 21-1a) has a knife-like blade that can be moved up and down. The blade is electrically joined to one of the switch terminals, and two jaws are electrically joined to the other terminal. When the switch is closed, the blade is caught between the jaws, and the terminals are connected together electrically.

A *pressure-contact* switch (Fig. 21-1b) has two or more contacts that can be pressed together to close the switch. Usually, one contact is fixed and the others are flexible. Since the contacts are electrically joined to the switch terminals, when the contacts are pressed together the terminals become electrically connected.

A *wiping-contact* switch (Fig. 21-1c) has one contact mounted on an arm that can be moved and other contacts that are stationary. The moving contact is slid from one stationary contact to another; that is, it wipes the stationary contacts.

Although the three contact methods described are most common, there are other methods. For example, one contact method (Fig. 21-2a) makes use of mercury, which is a liquid metal. The mercury and the fixed contacts are inside of a bulb. When the bulb is tipped, the mercury (which is a conductor) flows over the fixed contacts and acts as a moving contact to connect the fixed contacts electrically.

Other switches (Fig. 21-2b) have two or more separated contacts mounted in a gas-

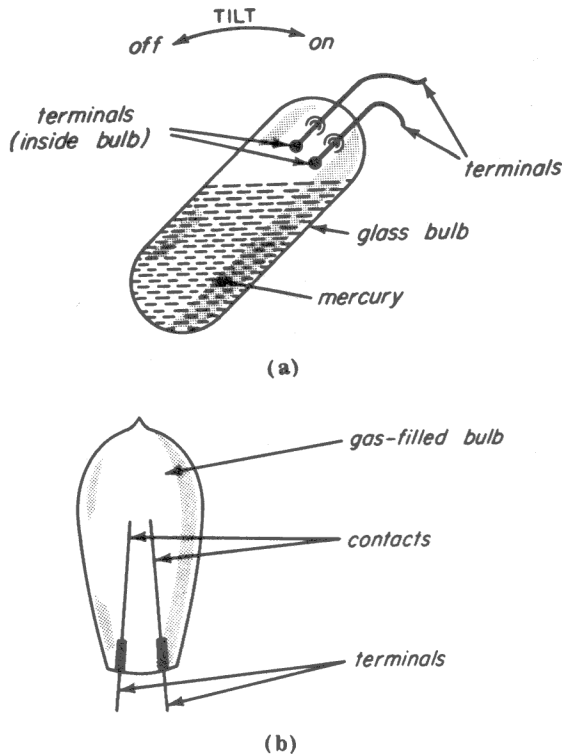


Fig. 21-2

filled bulb. The gas ionizes when the voltage across the terminals exceeds a certain value, and then the gas acts as a conductor to electrically connect the switch terminals.

An electron tube can serve as a switch. The contact method is electron flow from cathode to plate. The plate is one switch terminal, and the cathode is the other terminal. While the grid voltage is highly negative with respect to the cathode, no current flows and the switch is opened. When the grid voltage becomes more positive, current flows, and the switch is closed. As you learn more about switches, and use them, you will probably discover some more interesting and unusual contact-methods.

21-2. KINDS OF SWITCHES - SWITCH ACTION.

There are pushbutton switches, lever switches, slide switches, toggle switches, key switches, rotary switches, etc. Switches are made to be operated in a number of different ways, and so there are several kinds

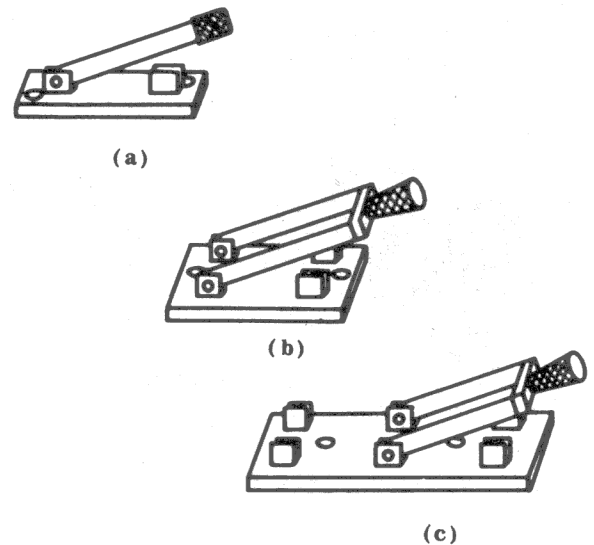


Fig. 21-3

of switches to learn about. The way in which a switch handle is made to operate the contacts is referred to as the switch's *action*. We say that the handle *actuates* the contacts.

Lever Action. The *knife switch* (Fig. 21-3a) is simple to understand. When the lever part, called the blade, is moved down into the jaws, the switch is closed. Of course, this switch makes use of the knife-contact method. Knife switches may have more than one blade (Fig. 21-3b) but they seldom have more than four. Likewise, knife switches may have more than one set of jaws for each blade (Fig. 21-3c).

The knife switch is a lever action switch. Another lever switch is called a *toggle switch* (Fig. 21-4a). All toggle switches are not exactly alike, but all are made to be operated in exactly the same way (Fig. 21-4b). The lever consists of the handle and the body. The lever is supported at the point where it passes through the switch housing. This point is a pivot. As the handle of the lever is moved *down*, the body of the lever moves *up*. The ball on the end of the lever, operates one of several kinds of contact mechanisms. Both pressure contacts and wiping (sliding) contacts are employed in toggle switch contact mechanisms. Wiping contacts are used more often.

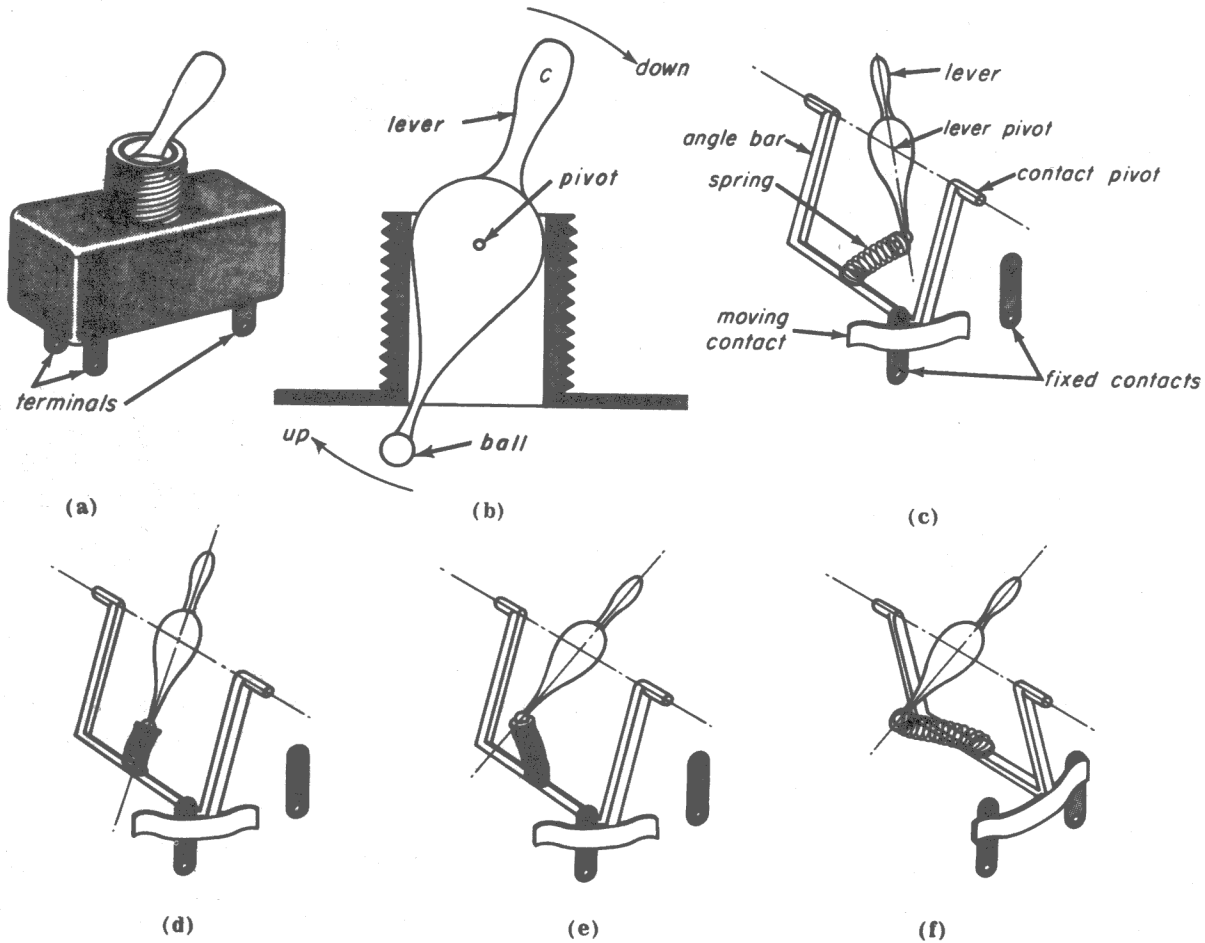


Fig. 21-4

The toggle switch shown in Fig. 21-4c to f uses the wiping contact method. In Fig. 21-4c, the pressure of the spring against the angle bar to which the moving contact is attached holds the switch in the open position. When the handle is pushed in direction E until the lever is vertical, the spring is fully compressed (Fig. 21-4e), the spring is pushed through to the other side of the angle bar. As a result, the compressed spring is now exerting pressure in a direction opposite to the pressure exerted in Fig. 21-4c. The force of the compressed spring against the angle bar causes the angle bar to pivot and force the moving contact in direction E. As a result, the moving contact touches both the fixed contacts and the switch is closed. The toggle switch may be said to have a double joint because it has one joint that the lever turns on and a second joint on which the angle bar and contact turn or move. It is this double jointed spring action that sets the toggle switch apart from other lever switches.

The *key* (Fig. 21-5) used by telegraph operators to tap out the dots and dashes of their code messages is actually a switch. It is a lever switch employing pressure contact. While you press upon the handle, the terminals of the key are electrically connected; they are disconnected when you let go of the handle and the lever springs back to its normal position. The key is a momentary-contact switch with *spring return* action. There are other momentary-contact switches. Some are *normally opened* (open when they are not operated) like the key, and others are *normally closed*.

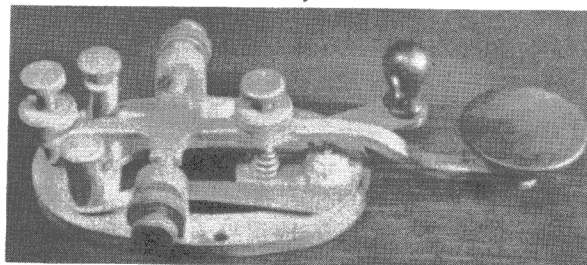


Fig. 21-5

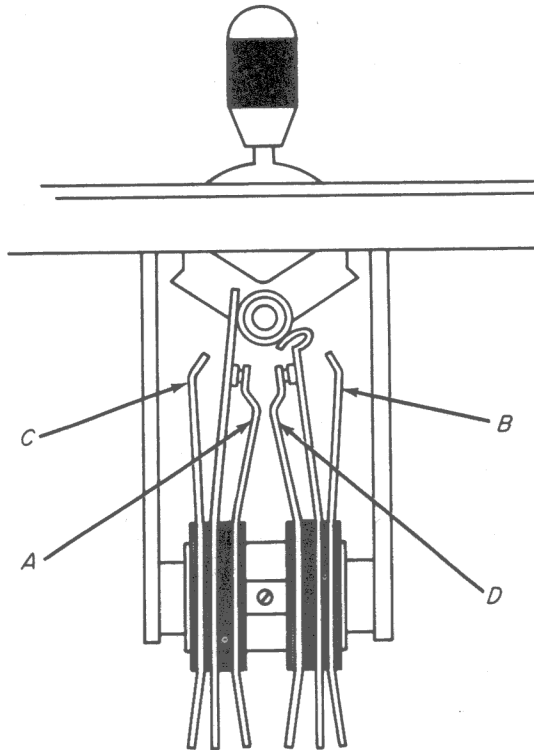


Fig. 21-6

The lever switch found on telephone switchboards and on business office intercommunication units (Fig. 21-6 and 7) is also called a key. Unlike the telegraph key, it is not always a momentary contact switch — though it may be. And when it is a momentary contact switch, it may be normally opened or it may be normally closed.

The switchboard key shown in Fig. 21-6 is a heavy-duty switch; it is typical of keys found in telephone equipment. When the lever

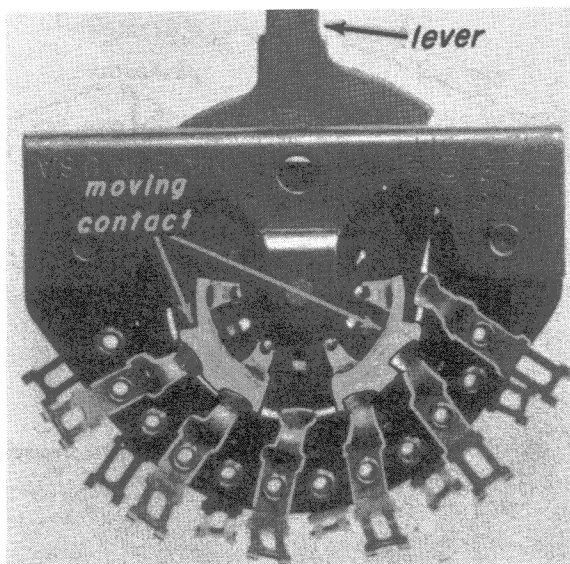


Fig. 21-7

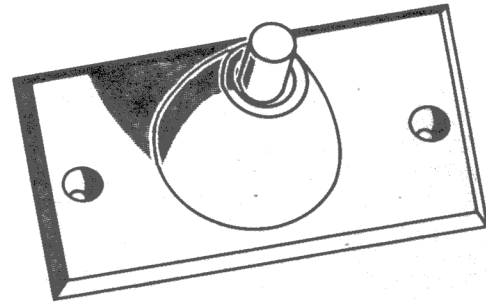


Fig. 21-8

is moved in one direction, the cam moves the spring contacts against the fixed contacts A and B. When you let go of the lever, the cam remains in this new position; the contacts remain connected.

The cam pushes the flexible contact against fixed contacts C and D when the lever is moved in the opposite direction. The lever does not remain here after you let go; the spring pushes it back and the contacts disconnect. Moved in one direction, the lever operates a momentary contact switch. Moved in the other direction, it operates a *locking contact* switch. Pressure contacts are employed.

The key of Fig. 21-7 employs wiping contacts. It is the key found in office intercommunication equipment. When you push the lever, it turns the moving contact and causes it to wipe against fixed contacts. This key, too, may be either a momentary contact or a locking contact switch.

Push Action. A doorbell button (Fig. 21-8) is a push-action pushbutton switch. In push-action switches, a moving contact is pressed against a stationary contact. When you let go of the button, the moving contact springs back. The doorbell button is a momentary-contact, spring-return, pressure-contact push-action pushbutton switch. Still, it remains a common door button. The complicated terms describe a simple device.

Actually, these terms are not all needed at one time. You use the term that describes the switch quality you are most concerned with. You call a doorbell button a doorbell button if you want to say that it is a button found on door jambs and used to ring a bell. You call it a spring-return switch if you want to say that it contains a means of pushing the button back to you after you have pushed it in with your finger and let go.

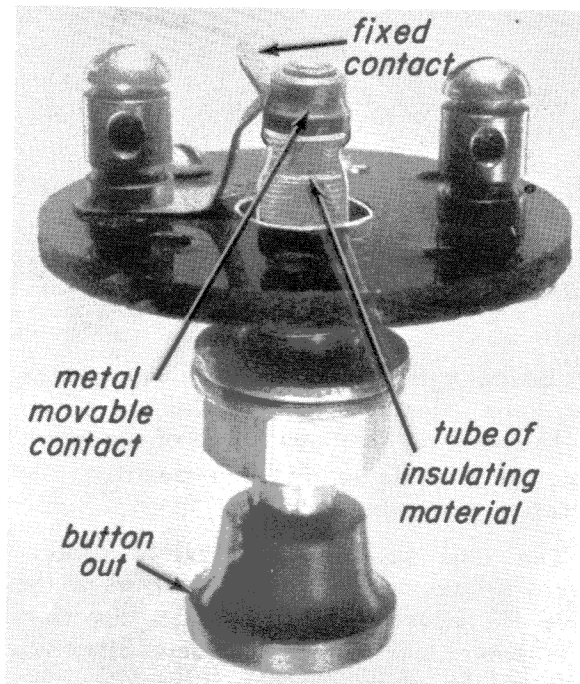


Fig. 21-9

A push-action switch without its own means of returning its handle is a *push-pull* switch (Fig. 21-9). It is *off* when the knob is pushed in, *on* when the knob is pulled out. Like the doorbell button, it is a push-action pressure-contact switch. Unlike the doorbell, it is not a push-button, spring-return, or momentary-contact switch. In the *in* position (off), the insulated part of the movable contact is forced against the stationary contact. In the *out* position (on), the conducting part of the moving contact is against the stationary contact.

A row of switches that has one mounting, common to all, is called a *switch bank*. Push switches mounted in a bank can have a greater variety of actions than can a single push switch. A bank of pushbutton switches of the type shown in Fig. 21-10 can have any combination of four separate actions.

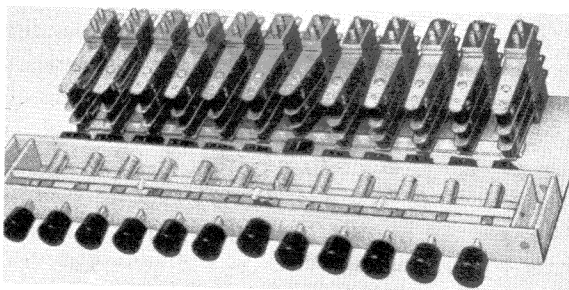


Fig. 21-10

1. Momentary contact action, in which you push the button in and it springs out when you release it.

2. Locking action, in which the button locks when you push it in, and springs out when you push a second button that, in turn, locks *in* until you push a third button. (One button is always in.)

3. Release-lock action, in which the button is pushed all the way in, then comes part way out and locks. When the button is pushed again, the lock is released and the button comes all the way out.

4. Accumulative locking action, in which the buttons lock one after the other as you push them in, then spring out all together when you push the release button provided for this purpose.

The pushbutton bank of Fig. 21-10 employs pressure contacts. The bank of Fig. 21-11 employs wiping contracts. It is the

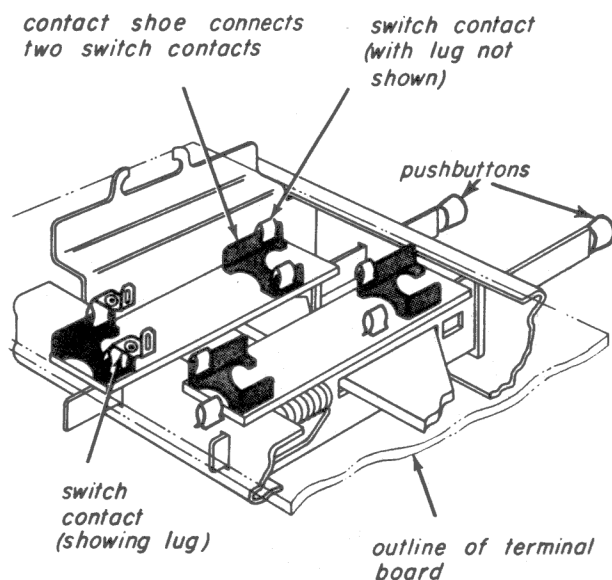


Fig. 21-11

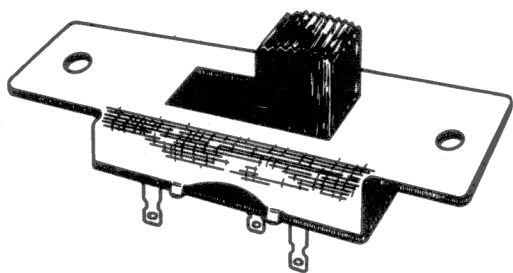
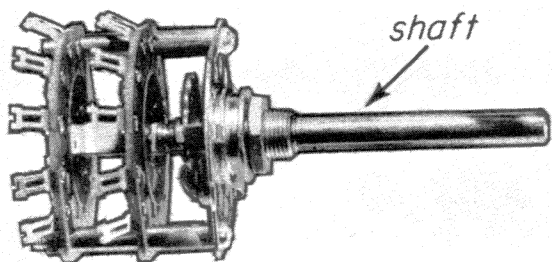


Fig. 21-12

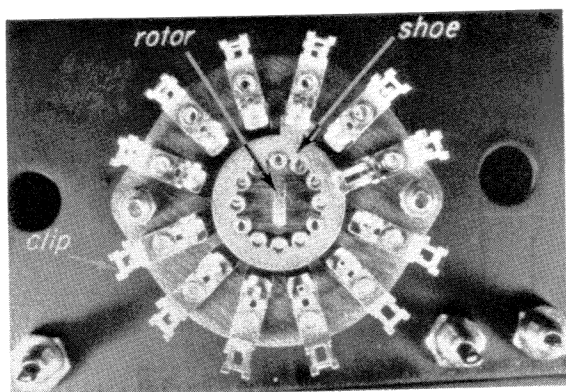
kind of pushbutton bank that is found in radios with pushbutton tuning. The wiping contact does not turn like most wiping contacts — instead, it slides straight in and out between the fixed contacts.

Slide Action. A slide action switch (Fig. 21-12) is one in which the handle slides to actuate the contacts. The contacts may or may not slide. They may be either wiping or pressure contacts. The slide switch shown in Fig. 21-12 is about the size of a toggle switch.

Rotary Action. A switch with contacts that turn on a shaft is called a rotary switch (Fig. 21-13a). You actuate the contacts by rotating (turning) a knob attached to the shaft.



(a)



(b)

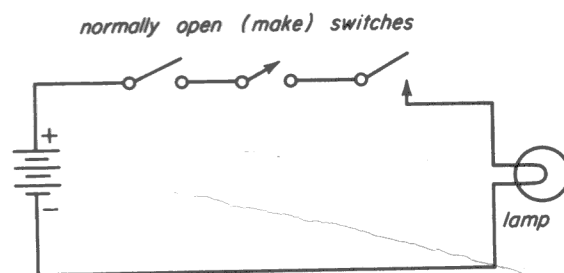
Fig. 21-13

A number of contacts (Fig. 21-13b) are mounted on a ring-shaped piece of insulating material. This is called a *stator* because it remains stationary. The contacts shown are jaw-shaped and are generally called *clips*. The moving contact, which wipes between the jaws of the clips, is called a *shoe*, or *segment*, and it is attached to a disk-shaped piece of insulating material, called a *rotor* — so called because it rotates when the switch is operated.

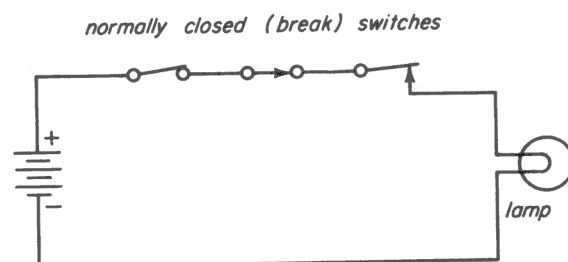
The rotor is attached to the shaft and the shaft is fitted with a knob. To operate the switch, you turn the knob, which turns the shaft, which turns the rotor, which rotates the segment, which contacts the clips held stationary on the stator.

21.3. THROWS, POLES, AND BASIC SYMBOLS

Three forms of the basic schematic symbol for a switch are shown in Fig. 21-14a. As you see, the fixed contact is represented by a circle or by an arrow. The moving contact is represented by a slant line when the switch is open. Where a circle represents the fixed contact, an arrow may appear on the moving-contact symbol. Where an arrow represents the fixed contact, no arrow appears on the moving-contact symbol. As drawn in *a*, the symbols indicate a normally



(a)



(b)

Fig. 21-14

open switch — a switch that *makes* (makes contact) in the *on* position. At *b*, the same symbols are drawn to indicate switches that *break* in the *on* position.

The moving-contact symbol represents a switch lever that can be moved up and down, like a knife switch blade, to connect or disconnect the switch terminals. *Throw* is the word used to describe the act of moving a switch lever to either the open or the closed position. You say *throw the switch*. What you mean is *change the position of the switch handle*.

Switches are described by the number of their throws. The number of throws equals the number of *on* positions. The switch in Fig. 21-14 is a single-throw switch.

A double-throw switch has two *on* or *make* positions. It may or may not have a separate *off* position. A triple-throw switch has three *make* positions.

The symbols of Fig. 21-15 are different ways of showing double-throw switches. With three positions, you throw from the first position (make to terminal 1) to the second position (break) and then you throw a second time to the third position (make to terminal 3). The second or center position of a three-position double-throw switch is always an *off* position. Even if a three-terminal switch does not have a center (*off*) position, it is still called a double throw switch because the moving contact makes to two different terminals. However, such a switch has only one actual throw. Where there are two positions, you throw from the first position (make to terminal 1) to the second position (make to terminal 3) and then, if you throw a second time, the moving

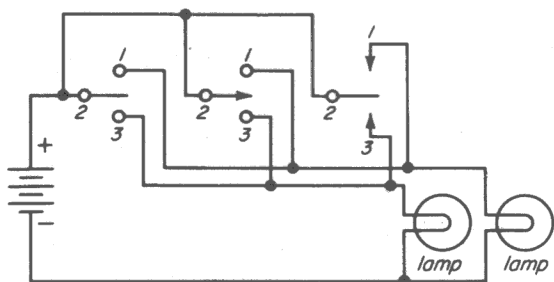


Fig. 21-15

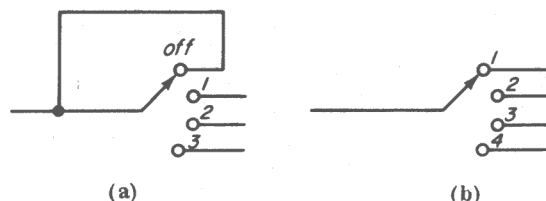


Fig. 21-16

contact returns to the original position (make to terminal 1).

Some switches, especially rotary switches, have many throws. Figure 21-6a shows the symbol for a four-throw rotary switch. Although it is wired so as to have only three *make* positions, the *OFF* position could be wired as a *make* position. The four-throw switch in Fig. 21-16b is wired with all four contacts as *make* positions. A good rule of thumb is that the number of throws equals the maximum number of possible *make* positions.

The term *throw* is awkward when it is used to describe a many-contact switch. In practice, it is not always employed. The term *position* takes its place.

A switch is said to have a *pole* for every one of its moving contacts. You say that the symbol of Fig. 21-16 represents a *single-pole, four-throw switch*. Figure 21-17a shows the symbol for a double-pole, single-throw switch. The moving contacts are connected with a broken line to indicate that both moving contacts are actuated at the same time by a single handle; *b* shows the symbol for a double-pole, double-throw switch; *c* shows the symbol that represents a four-pole, three-throw rotary switch.

Where a switch has momentary contact action, the symbol representing a fixed con-

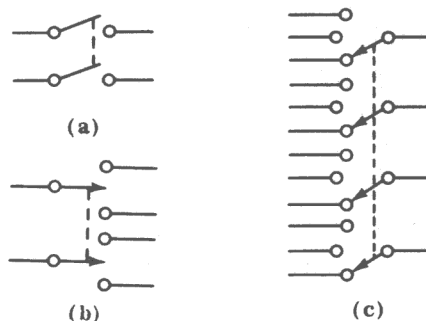


Fig. 21-17

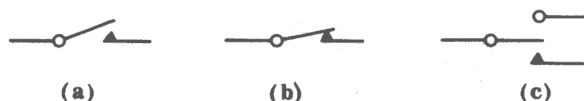


Fig. 21-18

tact is often drawn as shown in Fig. 21-18; *a* shows the symbol for a single-pole, single-throw, normally open, momentary-contact switch; *b* shows the symbol for a normally closed, momentary-contact switch; *c* shows the symbol for a single-pole, double-throw switch with momentary-contact action in one throw and locking action in the other throw. Circles, rather than arrows, always appear with the triangle-shaped momentary-contact symbol.

21-4. SOME SIMPLE SWITCHING CIRCUITS

The simplest possible switching circuit employs the single-pole, single-throw on-off switch (Fig. 21-19*a*). This circuit fulfills the basic function of a switch — to open and close a circuit. It does nothing more. However, a switch with more than one throw can perform a secondary switch function — selection. Figure 21-19*b* shows a single-pole, double-throw switch wired to select between two lamp circuits — to light the red lamp in one throw and the white lamp in the other throw. While the switch is in one throw, the red-lamp circuit is closed; at the same time, the white-lamp circuit is open. In the other throw, the red-lamp circuit opens and the white lamp circuit closes. The switch with more than one throw *selects* by opening and closing circuits in one operation. It performs the secondary function — selection — by means of the basic function, opening and closing.

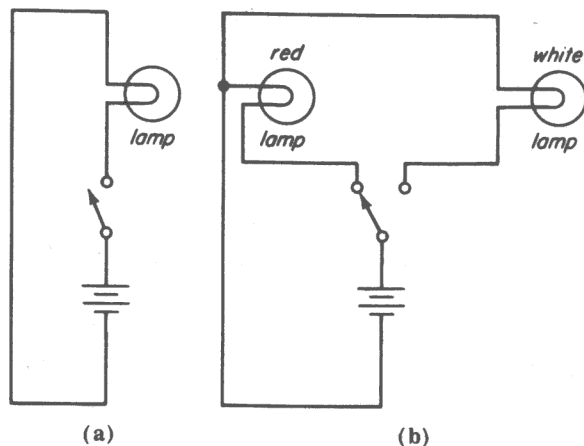


Fig. 21-19

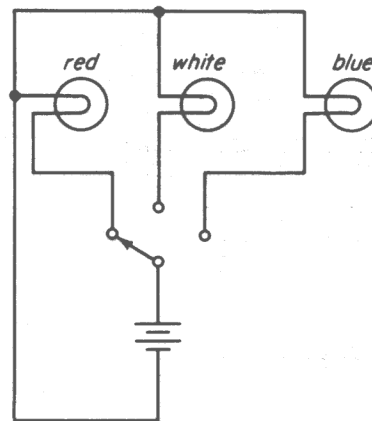


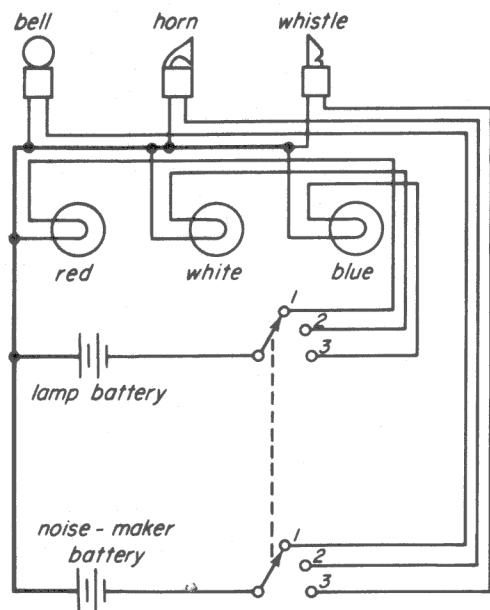
Fig. 21-20

A switch of many throws (multithrow or multicircuit switch) closes one or more of its circuits while holding all the others opened. Figure 21-20 shows a three-throw rotary switch wired to select one of three colored lamps — red, white, or blue. When the switch is in one throw, the red circuit is closed while both the white and the blue circuits are open. In the white throw, the red and blue circuits are open; and in the blue throw, the red and white circuits are open. A multipole switch can perform both switch functions; make-break and select. It can do so in several circuits at once. Figure 21-21*a* shows a three-throw, two-pole switch. One pole is wired to select any one of the three lamps — red, white, and blue. The other pole is wired to select one of three noise makers — a bell, a horn, and a whistle. The first pole selects the red lamp at the same time that the second pole selects the bell, etc. In switch position 1, the red lamp lights and the bell rings. In position 2 the white lamp lights and the horn toots. In switch position 3, the blue lamp lights and the whistle blows.

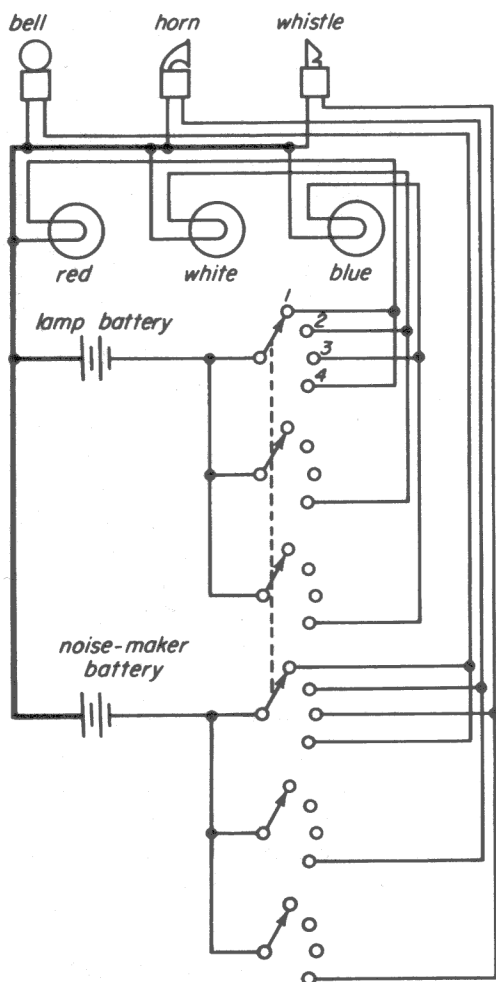
To extend these principles somewhat, the lamps and noise makers can be wired, as shown at *b*, with a four-throw, six-pole switch. In position 4, the bell rings, the horn toots, the whistle blows, and the lamps light up — red, white and blue.

21-5 PLUGS, JACKS, AND JACK SWITCHES

Figure 21-22*a* shows a simple plug and jack — a device to connect radio wires together without the use of tools. Since you

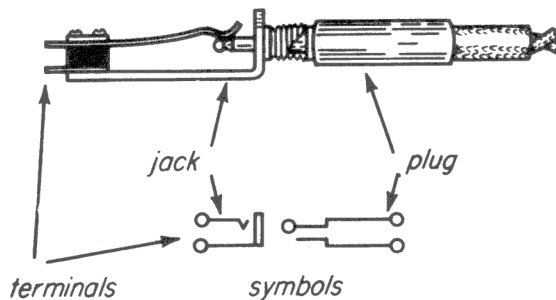


(a)

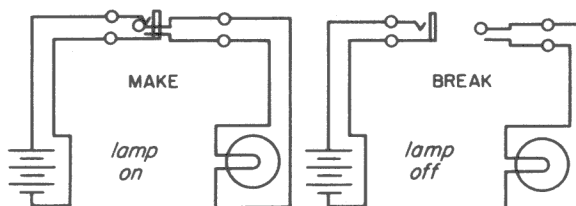


(b)

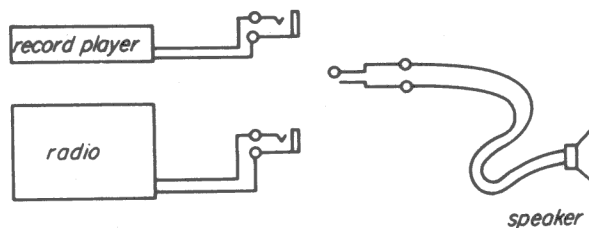
Fig. 21-21



(a)



(b)



(c)

Fig. 21-22

can make or break a circuit with the plug and jack (Fig. 21-22b), it performs the basic function of a switch. This device can take the place of a switch. Figure 21-22c shows two jacks and a plug arranged so that a loudspeaker may be connected either to a radio or to a record player. Here, the jack and plug function as a circuit selector.

Some jack-plug combinations connect three wires instead of two. The plug in Fig. 21-23a has three separate sections insulated from one another. Each numbered section of the plug connects with the terminal of the jack with the corresponding number, as shown in the schematic symbol of Fig. 21-23b.

Some jacks have auxiliary switch contacts that operate when the plug is plugged

when a loudspeaker is plugged into a radio-output jack, the auxiliary contact closes and a green lamp lights.

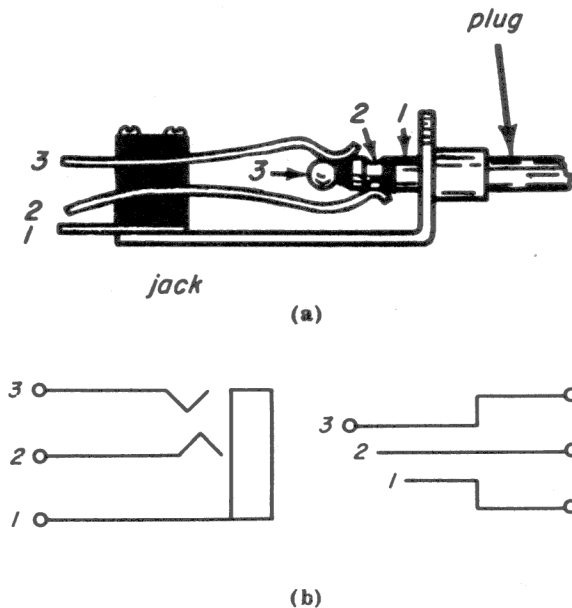


Fig. 21-23

in or plugged out. In Fig. 21-24a, inserting the plug separates terminal 4 from the auxiliary switch contact (terminal 3). Figure 21-24b shows such a jack wired so that

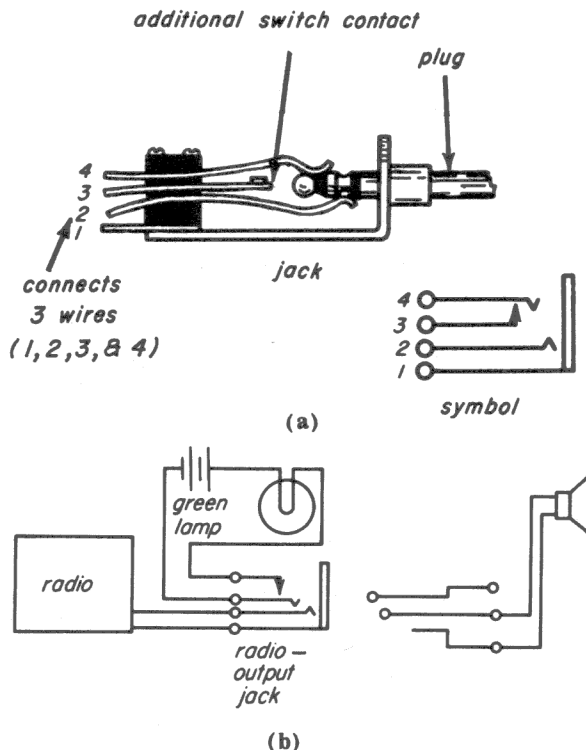


Fig. 21-24

21-6. ROTARY SWITCHES

Examine the rotary switch shown in Fig. 21-25. The rotary switch is probably more often found in radio receivers than any other kind of selector switch. It is convenient to operate, small, and can have many poles and throws. *Throw*, however, is a term seldom used to describe a many-contact switch. You say that it can have many positions.

The moving contact, shoe, or segment is mounted on a rotor and turns to contact the fixed contacts, or clips, which are mounted on the stator. A stator-rotor assembly is called a *section* or *wafer*. Wafers can be stacked, one behind the other, to make up a many-circuit switch. Each separate surface of a wafer — the front or rear surface,

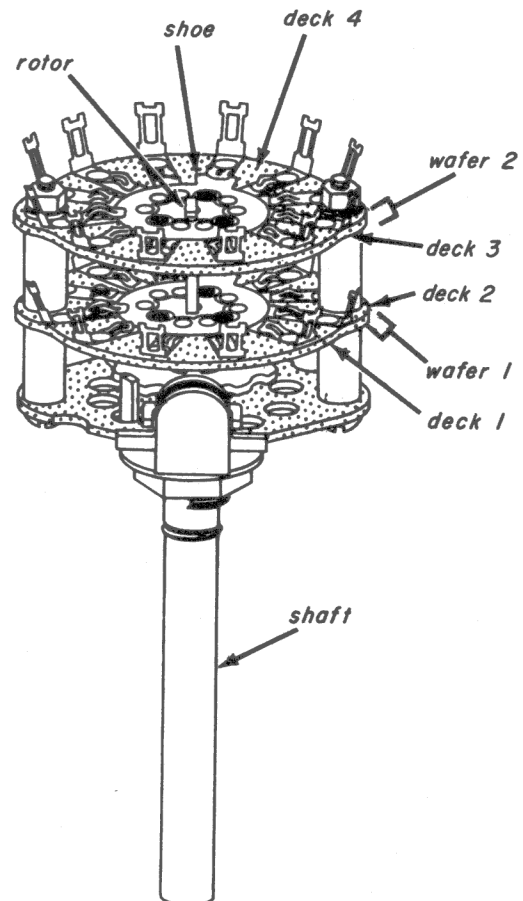


Fig. 21-25

alone — is called a *deck*. It is necessary to have a name for wafer *surfaces* because there may be a separate set of fixed and moving contacts on each surface of a single wafer. When this is so, you say, for example, that a certain contact is located on deck number 2, meaning that it is located on the rear surface of wafer 1.

As the shaft is turned to move the segments from one clip to the next, it must halt each time in exactly the correct position for the clip and segment contacts to meet. The means provided to make sure that the shaft halts in the correct position is called a *detent* or *index* (Fig. 21-26). The detent is part of the detent mechanism, which includes the face plate with its threaded pipe-like extension called a bushing. The shaft extends through the smooth hole in the bushing. The bushing, in turn, extends through a hole in the panel on which the switch is mounted. The switch is held in place against the panel by means of a nut that rides on the threaded outer surface of the bushing, and is screwed tight against the panel.

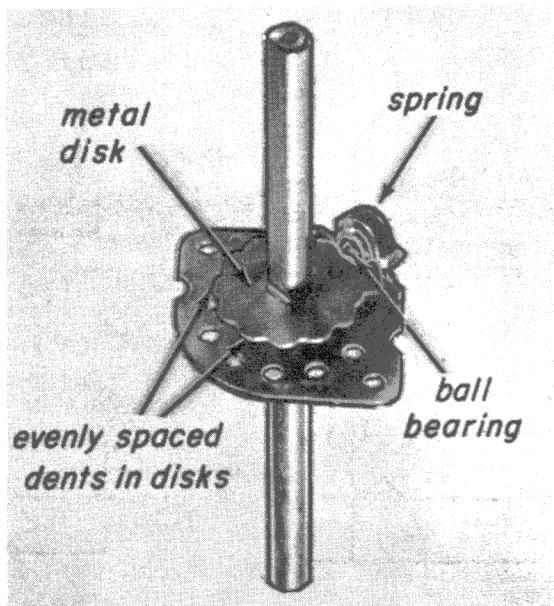
The part of the shaft that passes through the bushing is rod-shaped. It needs a round surface to turn easily against the smooth, round inner surface of the bushing. But the part of the shaft that passes through holes in the rotors usually is not round. It has flat sides. This helps the shaft to grip each rotor and cause it to turn as the shaft turns.

The face plate is firmly attached to the bushing. The wafers are attached, to the face plate by means of long screws that pass through the face plate, the wafers, and the tube-like spacers that hold the wafers apart.

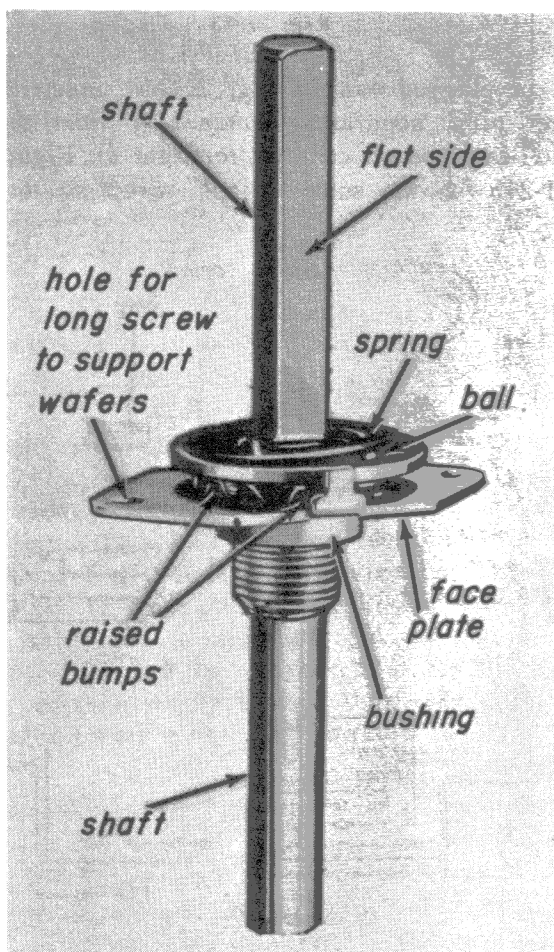
Where many wafers are stacked on a switch, a detent may appear at the rear of the stack as well as the face plate. This ensures positive snap action.

Two kinds of detent mechanism are illustrated in Fig. 21-26. At *a*, a metal disk is attached to the shaft. The rim of the disk is a series of evenly spaced dents. A ball bearing held by a spring presses against the dented rim of the disk. The spring and ball

unit is attached to the face plate and cannot move.



(a)



(b)

Fig. 21-26

As you rotate the shaft, the disk turns against the spring-loaded ball. And as the disk turns, the ball bumps from dent to dent, halting the shaft with each bump. In *b*, the spring and ball turn with the shaft, and bump against a circle of raised bumps stamped into the metal of the face plate.

The detent causes the shaft to halt at evenly spaced intervals, and, consequently, causes the segment contact of the rotor to halt at the same intervals. Since the clip contacts on the rim of the wafer are spaced for the detent halt-interval, the segment meets a clip at each halt.

Rotary switches usually have either six or twelve possible positions. With six positions, the detent is arranged to halt the shaft every one-sixth of a full circle, or every 60 degrees. (Since there are 360 degrees in a circle, one-sixth equals 60 degrees). With twelve positions, the detent halt-interval is every one-twelfth of a full circle, or 30 degrees.

Although a switch with 60-degree contact spacing has six possible positions, it need not have six actual positions. For example, if the rotation of the shaft is blocked to permit you to turn it only half way around, the switch has only three actual positions. The positions are still spaced at 60-degree intervals.

A device to block the rotation of a switch shaft is called a *stop*. Stops are built into the detent mechanism of Fig. 21-27*a*. Shown is a 12-position switch that is stopped down to allow only two positions. Stop *A* blocks rotation to the left when the lip part (*X*) of the detent disk hits the stop. Adjustable stops (Fig. 21-27*b*) permit a switch to be stopped down to any number of positions within the maximum possible number (usually six or twelve). One stop (*A*) is fixed. The other one (*B*) is movable; it can be placed to stop the shaft at any position.

21-7. SWITCH WAFERS

The heart of the rotary switch is the wafer. The makeup of the wafer determines the kind of switching operations a rotary switch performs. The manufacturer can vary

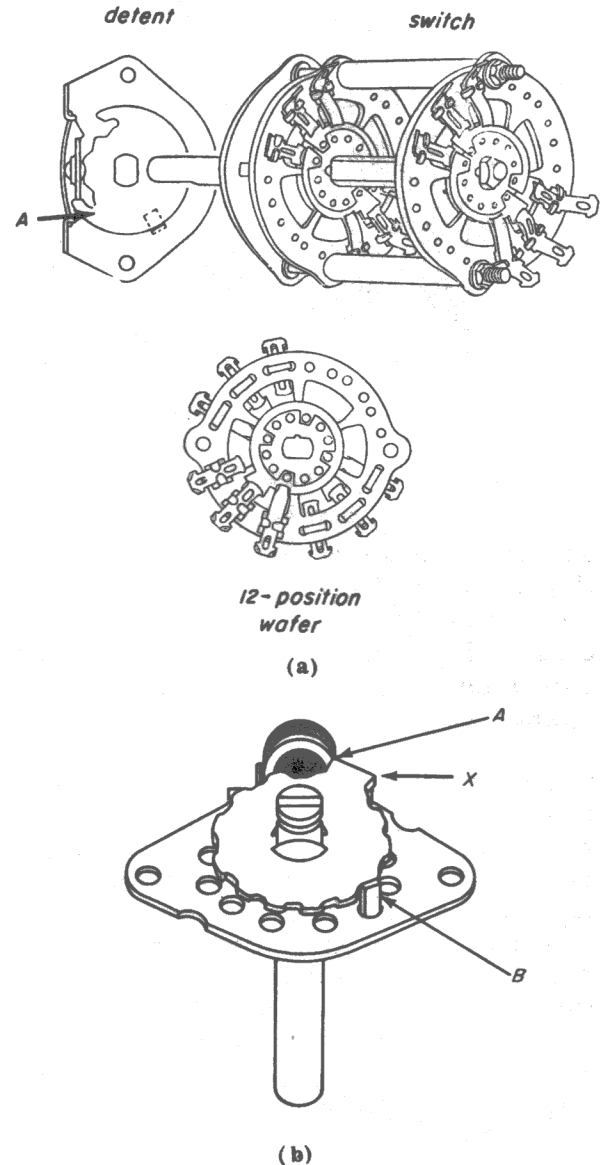


Fig. 21-27

the spacing of the wafer's clip contacts and the shape of its segment contacts to produce a great variety of switch operations.

Figure 21-28 shows a wafer with six clip contacts. The segment contact is shaped like a ring with a tooth. The clips are long enough to reach only the tooth, except for clip 1, which reaches the ring. The segment always contacts clip 1, no matter what position the rotor takes, but it contacts any other clip only when the rotor is in a position where the tooth and the clip to be contacted meet. Clip 1 is the moving contact terminal; all the other clips are fixed contact terminals. This wafer is used in a six-position single-pole switch with five throws

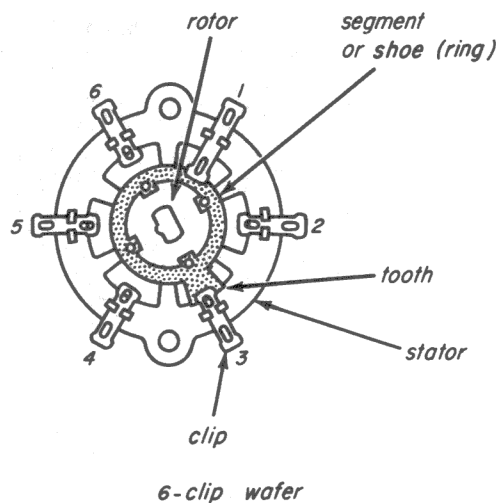


Fig. 21-28

and an off position. Off is the rotor position where the tooth of the segment meets clip 1 and the moving contact terminal is connected to itself. A two-pole six-contact switch can be built up of two such wafers stacked on the same shaft.

Another way to build a two pole, six position switch is to employ a single twelve-clip wafer (Fig. 21-29) in place of the two six-clip wafers and have two segments on the single wafer's rotor. The segments each look like half of the ring-shaped segment; each has a tooth. When the rotor is in position 1, tooth 1 meets clip 1 and tooth 2 meets clip 7; the switch is off. In position 2, tooth 1 meets clip 2, and tooth 2 meets clip 8, etc., etc. Stops prevent the shaft from turning more than half way around. Here you begin to see evidence of the great variety of switch operations possible with wafer-type construction.

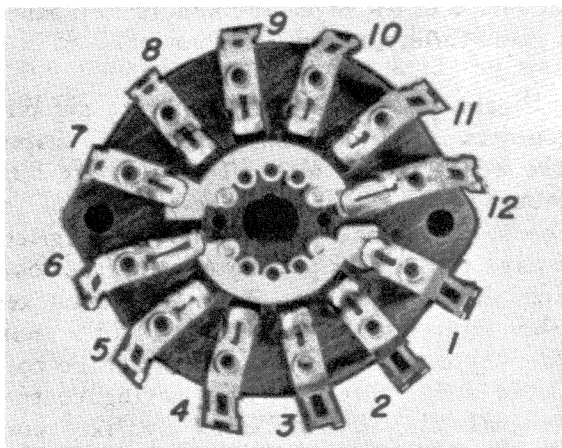


Fig. 21-29

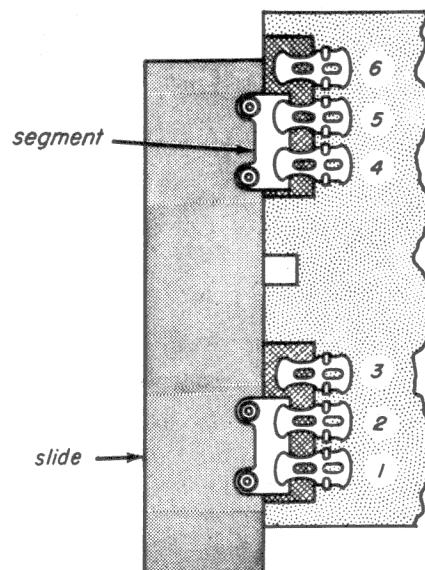


Fig. 21-30

Wafer-type construction is not limited to rotary action switches. Figure 21-30 shows a wafer belonging to a pushbutton switch bank. The shoe or segment slides to wipe the clip contacts rather than turn. Push-switch wafers generally have no more than two throws. However, they often have several poles. This wafer makes up a two-pole, two-throw switch. Clips 2 and 5 are the moving-contact terminals, because they are connected to one or another fixed terminal.

Such a wafer can be represented by the basic double-pole, double-throw schematic symbol (Fig. 21-31a). The special wafer symbol (b) is more usual, however, because it shows more information. It shows that the switch is a wafer switch, that it is not a rotary switch, that clips 2 and 5 are the moving contact terminals, and that when the button is pushed in, clips 2 and 3 and 5 and 6 are joined.

Figure 21-32a shows the symbol for a three-pole four-position rotary wafer. The actual wafer appears at b, and c shows two of these ganged (stacked on one shaft). Wafer symbols are little pictures of real wafers.

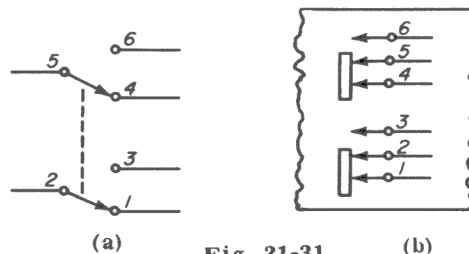


Fig. 21-31

That they picture the actual shape of the segment is a particularly helpful feature of wafer symbols. Knowing from a schematic how the shape of a segment produces a cer-

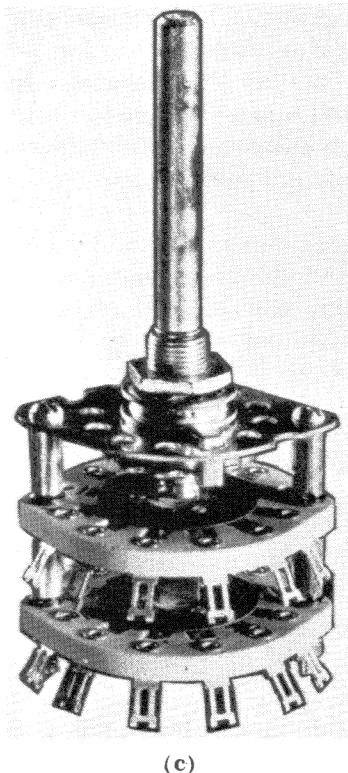
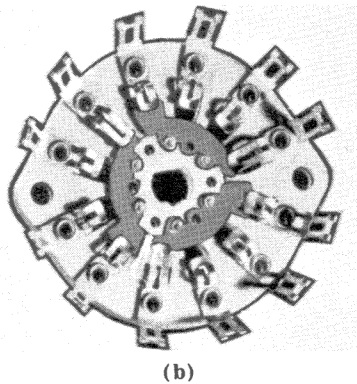
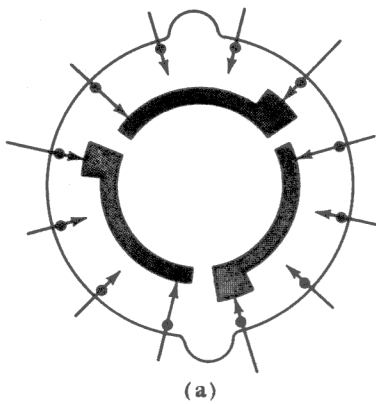


Fig. 21-32

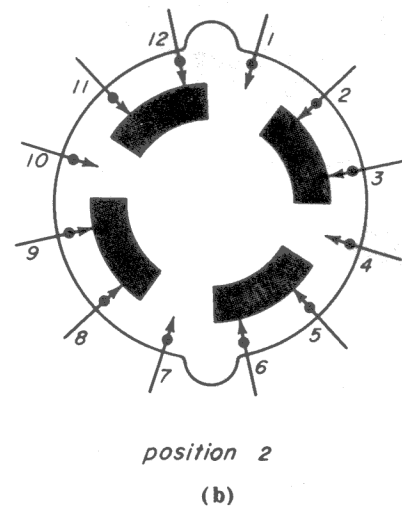
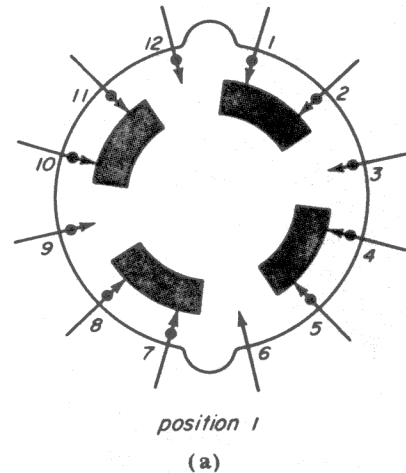
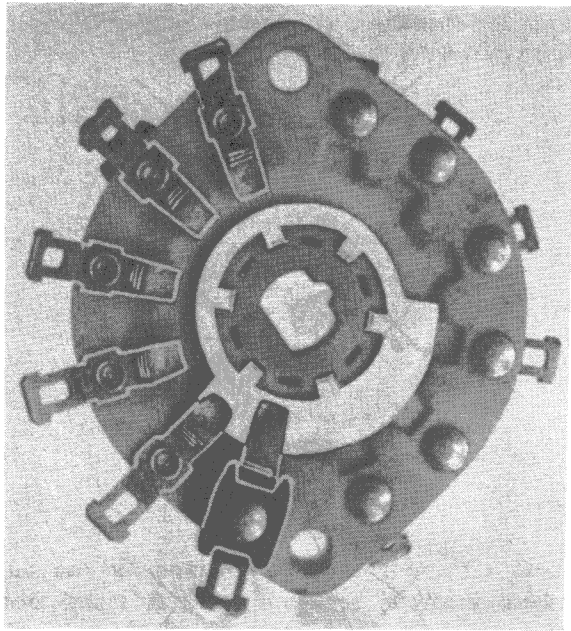


Fig. 21-33

tain kind of switch operation, you are better able to analyze the actual switch.

The shape of wafer segments is not limited to the ring and tooth design. The symbol of Fig. 21-33a represents a twelve clip wafer with four evenly spaced segments, shaped to join any two of the clips at a time. There is no ring and no long clip. The rotor has only two positions because the shaft of the switch to which it belongs is stopped down to two positions.

Figure 21-33a shows the rotor in position 1, b shows it in position 2. This wafer makes up a four-pole, two-position switch. Clips 2, 5, 8, and 11 are the moving contact terminals. Clip 2 is connected to clip 1 in position 1, to clip 3 in position 2, etc. — as follows:



(a)

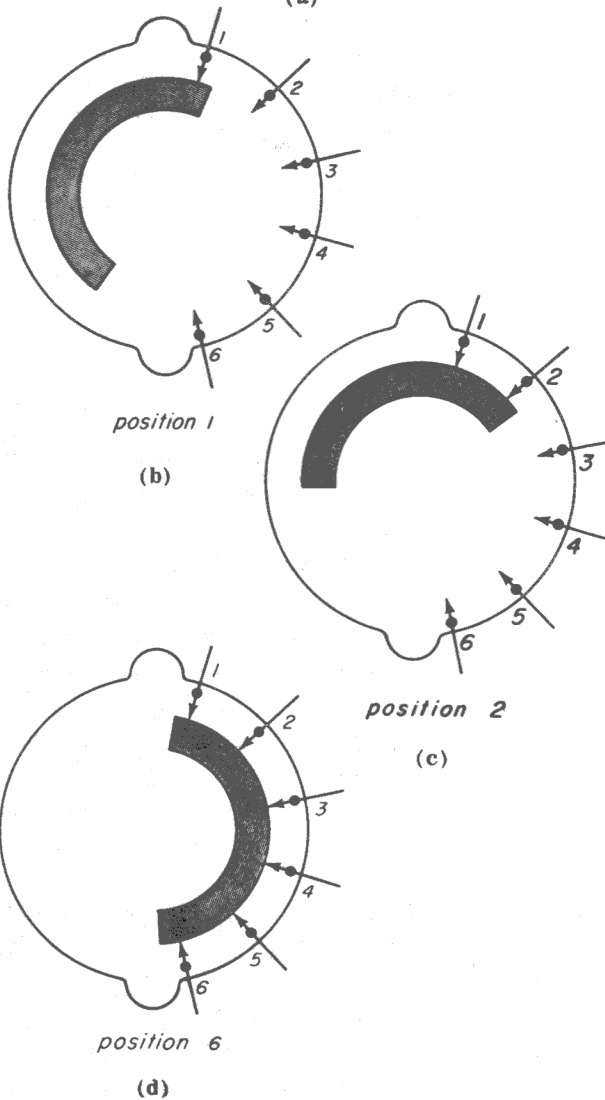


Fig. 21-34

		Position 1	Position 2
POLES	1	1 - 2	
			2 - 3
	2	4 - 5	
			5 - 6
	3	7 - 8	
			8 - 9
	4	10 - 11	
			11 - 12

Changes in the shape of segments, spacing of clips, and position of stops can change more than the number of poles and positions a switch may have. The segment in Fig. 21-34a is shaped like half of a ring; it has no tooth. The stator of the wafer holds six evenly spaced clips all mounted on one side of the stator. This is shown by symbol at b. At b, the segment contacts clip 1 and no other clip. None of the clips are joined. At c the symbol shows the rotor in position 2; the segment joins clips 1 and 2. As the rotor is turned to the next position and the next position — the next and then the next clip are joined to clips 1 and 2, etc., etc. — until, finally, in position 6 (d), all clips are shorted together. This segment can be called a shorting ring. It is awkward to describe the operation of the shorting rings in terms of throws and poles. To get the same kind of switch operation using an ordinary six-throw switch requires five poles.

A segment that is shaped like a ring minus a notch-shaped piece the width of a clip (Fig. 21-35) will join all clips but one. One

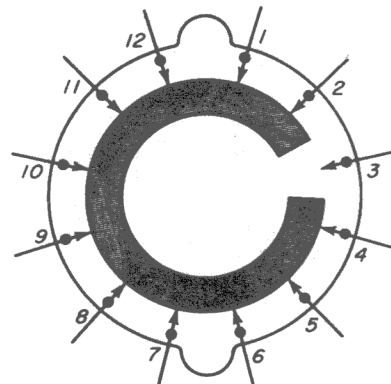
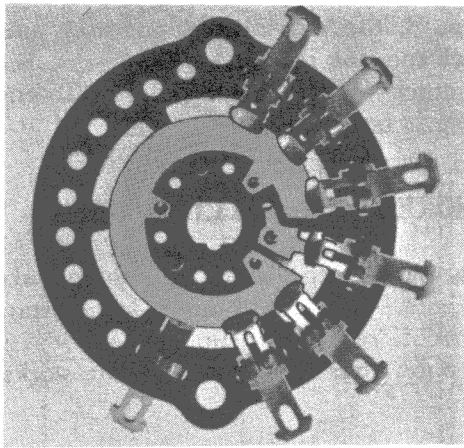
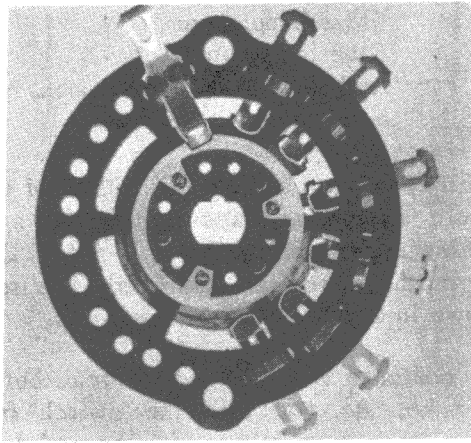


Fig. 21-35



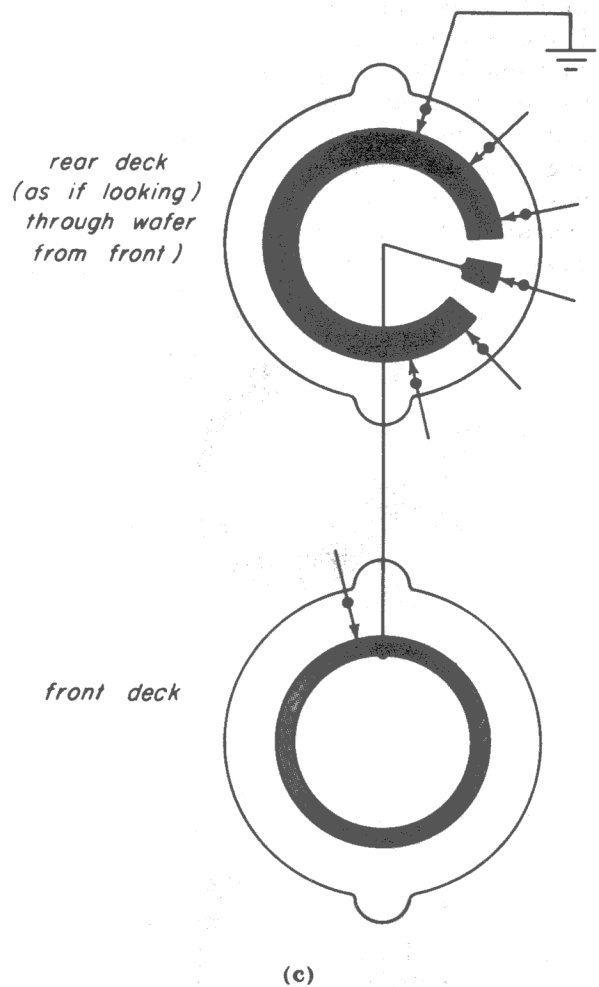
(a)



(b)

clip at a time disconnects from the others as the rotor turns from position to position. The operation of this segment is opposite to that of the ring and tooth segment, which connects one clip at a time.

The notched-ring segment in Fig. 21-36a also joins all clips but one. However, in this case, the one clip not joined to the others by the ring is contacted by another segment on the rotor. This segment, located in the notch of the ring, is tooth shaped and apparently not connected to anything. In fact, it connects to a second ring-shaped segment located on the other surface of the rotor on the opposite deck (Fig. 21-36b) of the wafer. A single clip on this deck contacts to the second ring; it makes contact in all switch positions. This clip is the moving contact terminal; the tooth is the moving contact. The notched ring joins all clips together except the one being contacted by the tooth.



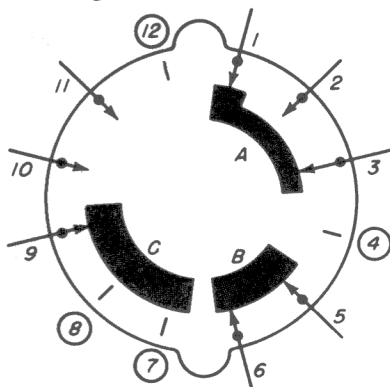
(c)

Fig. 21-36

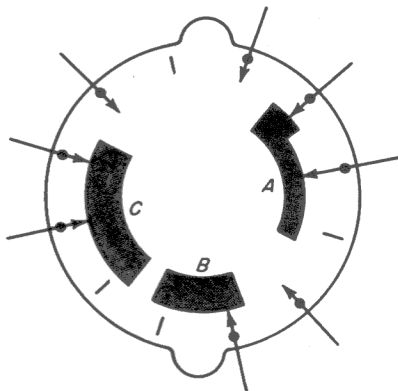
The wafer is shown by the symbol in c. The notched ring is called a *ground ring*. It is often grounded; one of the clips that contact it is, in many circuits, wired to ground. This kind of wafer is employed in your signal-generator hand switch.

Of course, when a wafer has several segments, each can have a different shape. The wafer of Fig. 21-37a belongs to a three position switch. The wafer has room for twelve clips, but only eight (1, 2, 3, 5, 6, 9, 10, and 11) are in place. The circled numbers indicate the missing clips (4, 7, 8, and 12) and show where on the wafer they would appear. Three segments (A, B, and C) are employed. Each has a different shape. A has the ring and tooth shape; it is long enough to reach three clips. B has the shorting ring shape; it reaches two clips. C, too, is shaped as a shorting ring, but it reaches three clips instead of two. Figure

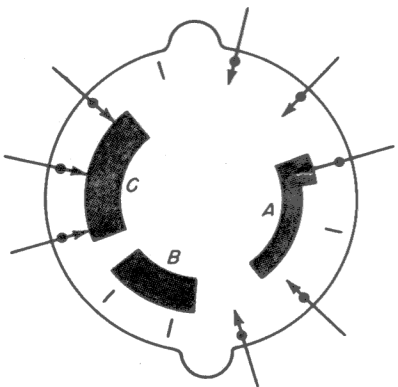
21-37a shows the rotor in switch position 1; b shows it in position 2; and c shows it in position 3. Note that clips 7 and 8 are left out to make room for segment C when the rotor is in position 1, and to make room for segment B in position 3. This is often the case with rotary switch wafers. It is not necessary to make room for segment A because, although it reaches contact 5 in



position 1
(a)



position 2
(b)



position 3
(c)

Fig. 21-37

position 3, the five clip is not long enough to reach the ring part of tooth-and-ring wafer, A. Contact 4 is left out (as is 12) simply because it is not needed.

21-8. MORE SWITCHING CIRCUITS

Now, back to the lamps and noise makers. When last considered, these were arranged in a circuit reproduced in Fig. 21-38a with a six pole, four throw switch that works as follows:

Position	On
1	Red lamp, bell
2	White lamp, horn
3	Blue lamp, whistle
4	Red, white, and blue lamps, bell, horn, and whistle.

A single wafer can take the place of this six pole switch and accomplish the same switching operations (Fig. 21-38b). Both decks of the wafer are employed. The rotor is shown in each of the four positions.

The contacts are arranged to break before they make. As you turn the switch from position one to position two, the red lamp goes out and the bell stops ringing. For a moment there is no light, no noise. This dark and silent moment starts the instant that the segment breaks contact with the first clip. It continues only a moment and ends the instant the segment makes to the next clip, whereupon the white lamp lights and the horn starts blowing. The segment completely breaks from the red clip before it makes to the white clip. *Break-before-make* is the name given to this kind of contact operation. Most contacts operate this way. There is another kind of contact operation called *make-before-break*. If the switch of Fig. 21-38b had make-before-break contacts, the segment would be a bit longer. The operation would be as follows: As you turn from position 1 to position 2, the red lamp would remain lighted and the bell would continue to ring even past the instant the segment contacted the white clip. For a moment, the red and white lamps would glow together while the bell would ring and, at the same time, the horn would blow. The instant the segment broke from the red clip,

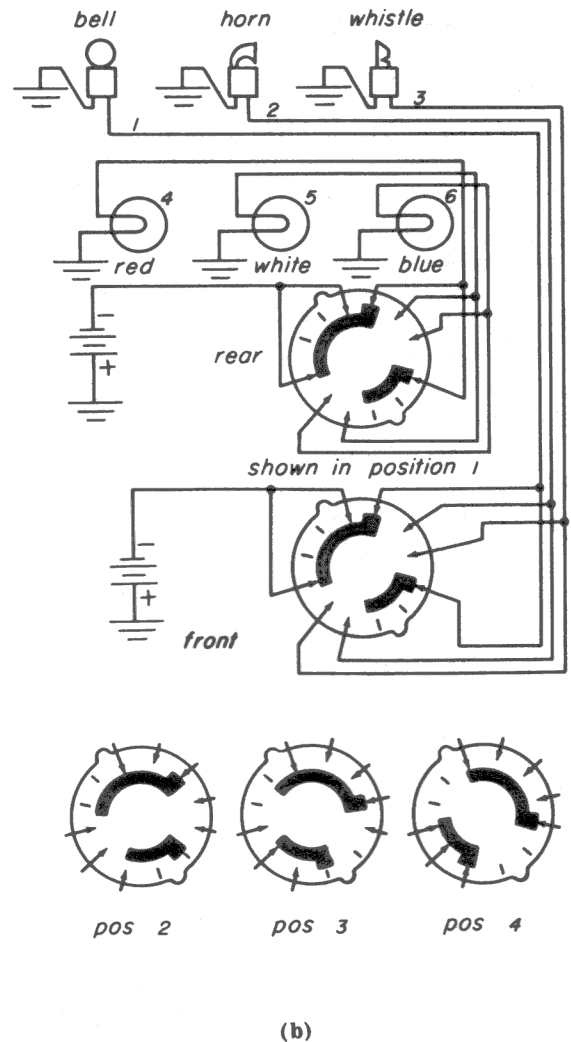
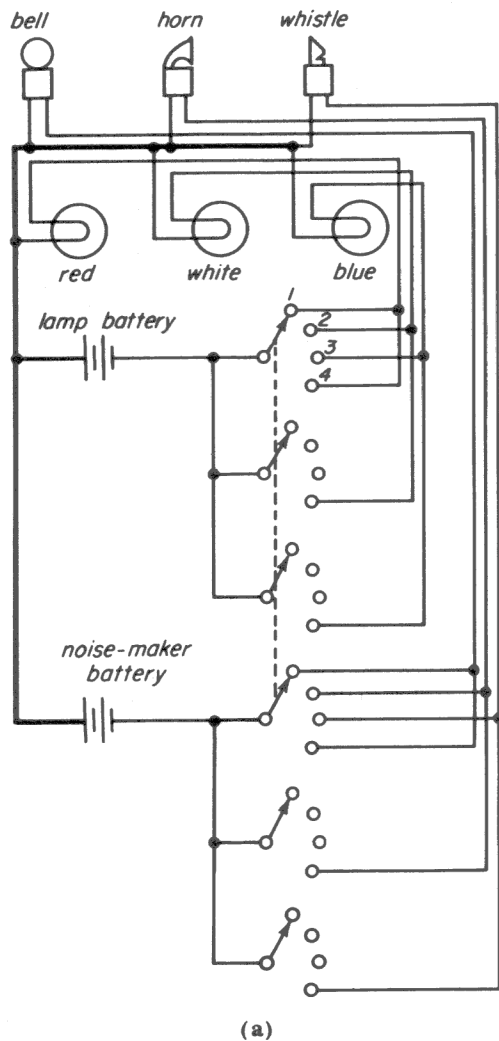


Fig. 21-38

the red glow and the sound of the bell would stop, leaving only white light and the sound of the horn. At no time, would there be complete darkness or complete silence.

In Fig. 21-39, a second switch is added to the circuit of Fig. 21-38b. The purpose of this switch is to make it possible to turn any one of the lamps or noise makers completely off so that it does not work in any position of the switch in Fig. 21-38. Here, a notched ring stator is employed because the purpose is to *disconnect* rather than to connect. The new switch has six positions, as follows:

Position	Off
1	Red lamp
2	White lamp
3	Blue lamp
4	Bell
5	Horn
6	Whistle

What would happen if the new switch were in position 3 and the switch in Fig. 21-38 were in position 3? The whistle would blow, of course, but the blue lamp would not light.

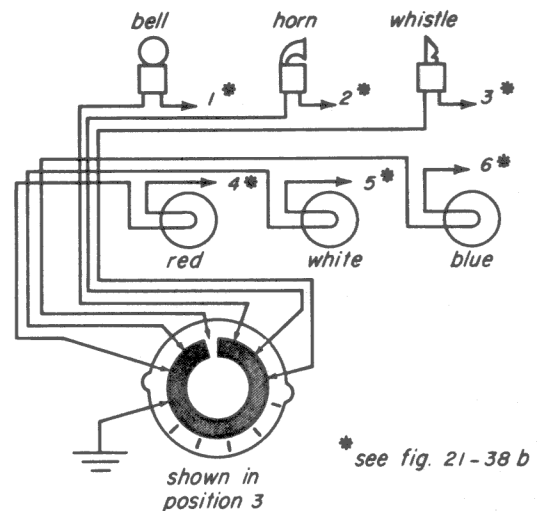


Fig. 21-39

21-9. POWER-HANDLING ABILITY

All switches cannot handle the same amount of current. The amount of current a switch can carry is determined by the size of the metal contacts. Larger contacts can carry more current. Each time switch contacts open, a spark jumps between them. The larger the current the larger the spark. Very small currents cause practically no spark. Light metal contacts are burned by the large spark caused by a large current — the contacts get pitted. A switch should not be allowed to carry more current than it is able to carry easily. That is, a switch designed for low current applications should not be employed in high-current circuits.

There is a limit, too, to the amount of voltage that can safely be placed across the terminals of a switch. Together, the current and voltage handling ability of switches is referred to as power handling ability ($P = EI$). The amount of voltage that can be handled depends upon the quality of the insulation and the spacing between contacts and between terminals. If too much voltage is applied, the insulation breaks down in a flash of light. We say that the switch *flashed over*.

Some switches employed in radio receivers handle *signal voltages* and *signal currents*. These are low voltages and currents. Some handle *B+* voltages (not too high) and *B+* currents (rather low). Others handle a-c power and filament power. The voltage is not too high but the currents are much higher than for *B+* or signal.

Radio-receiver rotary switches of the type described in this booklet are employed mostly in signal and *B+* circuits. Usually they cannot handle a-c power or filament power.

Figure 21-40 shows a switch widely employed to handle power in radio receivers. Where's the handle? There isn't any handle. This little switch attaches to a volume control or to a rotary switch. The handle of the rotary switch or the control is what actuates the contacts of the power switch. Usually it is a single-pole single-throw switch. It attaches to the shaft of the con-

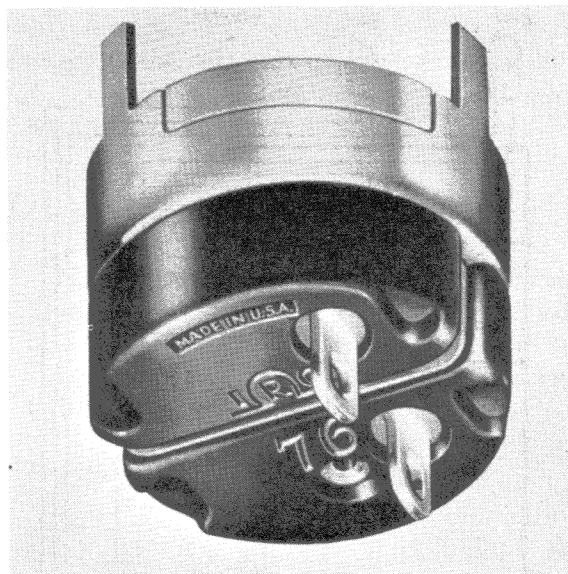


Fig. 21-40

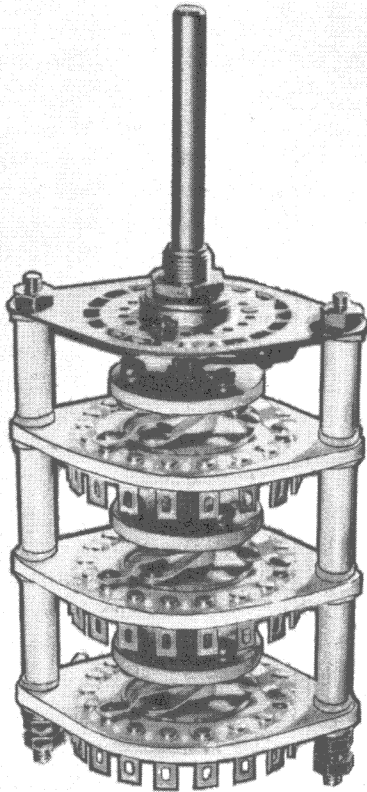
trol or the rotary switch. Used with a control, it is off in the full counterclockwise position of the control shaft and is on in all clockwise positions.

Although not needed in radio receivers, special rotary switches are available for power switching. Figure 21-41a shows such a switch and Fig. 21-41b shows an ordinary radio receiver rotary switch. Note the difference. The power switch has larger metal contacts, more insulation, and there is a larger space between contacts. The entire switch is larger.

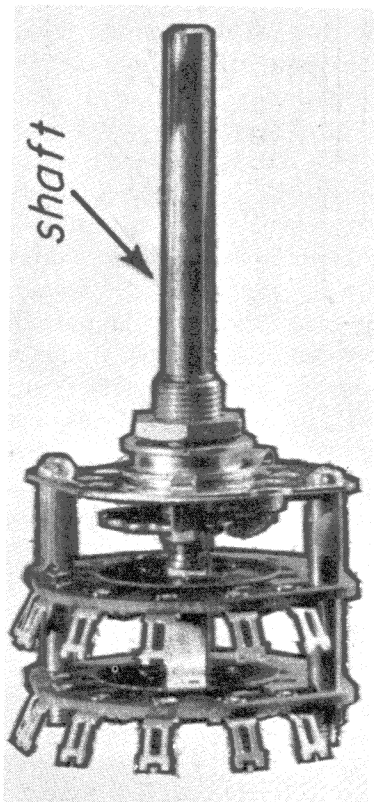
21-10. SWITCH TROUBLES—MAINTENANCE

Switches develop trouble in the contacts and in the contact-actuating mechanism. Contacts lose their spring tension and fail to close. Power-switch contacts get welded together by a hot spark and fail to open. Dirt and grime accumulates on contacts and makes contact unreliable — now you have it, now you don't. The springs in switch actuating mechanisms break and the handle fails to move the contacts. You throw the switch but nothing happens. The contacts remain in the open or closed position.

Where a switch is completely enclosed in its housing, not much can be done about these troubles. The switch must be replaced. However, much can be done with a rotary switch, where everything is exposed. Rotary-



(a)



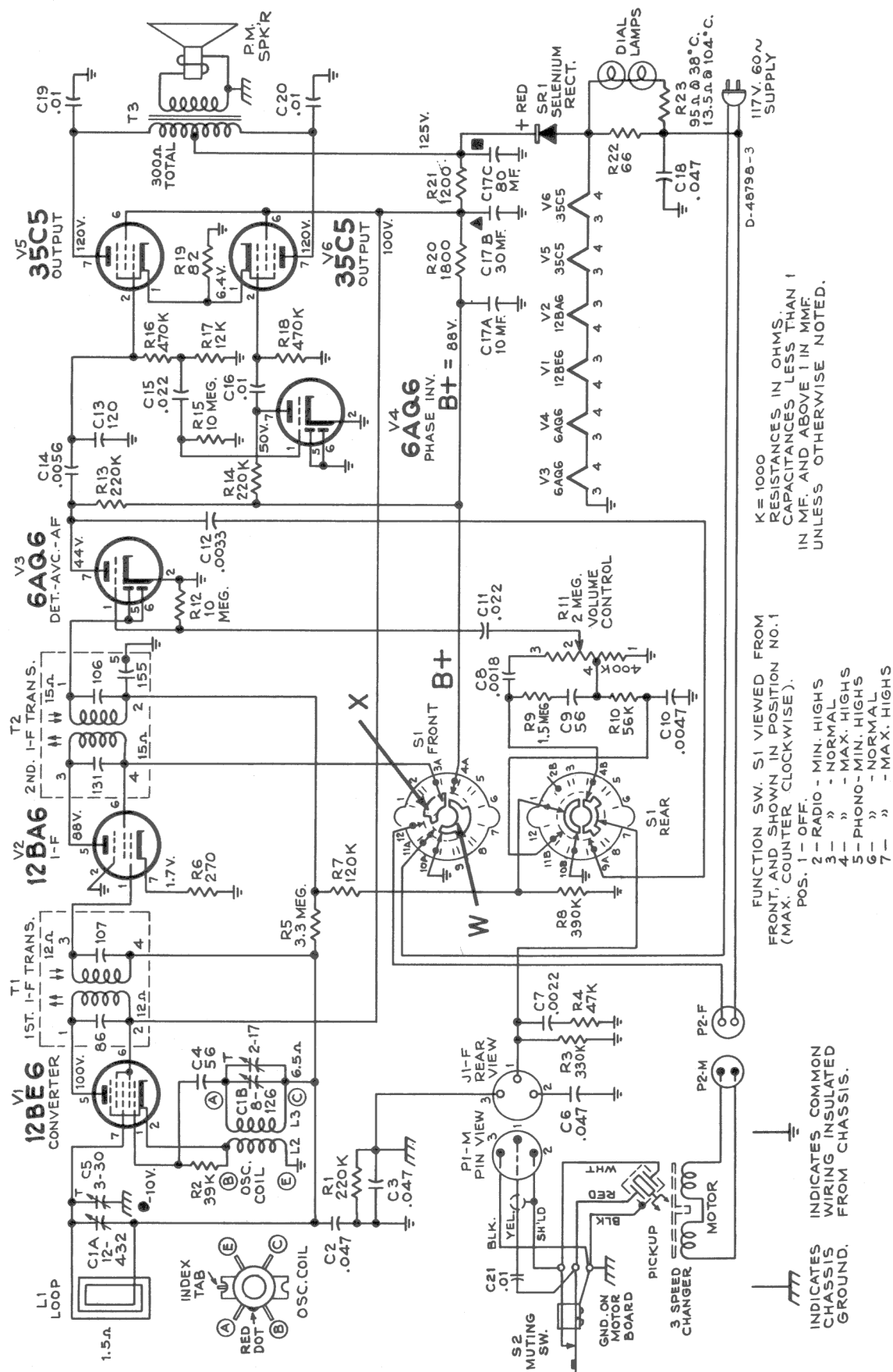
(b)

Fig. 21-41

switch detent mechanisms should be lubricated (greased) with a pure grade of grease (Vaseline is safe). To do so is a step towards minimizing wear. Wear on the detent causes loss of positive snap-action, thereby halting operation. The contacts do not halt in each position. The ball bearings of detent mechanisms especially need lubrication to enable them to turn in their sockets. Balls that are not free to turn tend to jump out of their sockets when the shaft is rotated. Then, of course, the detent-halting action is lost. If a ball falls out of a detent because of a lack of lubrication, it can be replaced. If a ball falls out because of a broken spring, it cannot be replaced unless the spring is also replaceable. Where they are not, the entire detent mechanism, face plate, and shaft are replaced. The original wafers can be used with the new shaft and face plate. Individual wafers can be replaced. This is easy to accomplish when the switch is not wired into a circuit. When a switch is wired in, it is sometimes as much trouble to replace a single wafer as it would be to replace the entire switch.

Rotary-switch contacts can be cleaned with special contact-cleaner preparations, which are sold by radio parts suppliers. Cleaning is done by applying the liquid cleaner to the contacts and then rotating the switch. If a dip contact gets bent away from the segment and fails to make contact, it is possible to bend it back in place. However, a degree of skill is required to do so. Practice on a switch you do not want before you try this on a switch you cannot afford to damage. Rotate the shaft to a position where the clip to be bent does not contact the segment — then bend. Clips have two finger-like parts. One finger presses against the other and against the segment, which is caught between them. As you push one finger toward the segment, you are pushing the other one away. For this reason, just the right amount of pressure is necessary — just enough to successfully bend the clip to the point where it will again contact the segment properly. Skill is required.

Unlike detent troubles, a bent clip causes an electrical defect (an open circuit), which must be located through troubleshooting methods.



Schematic Diagram—Chassis RC-1117A

Fig. 21-42

21-11. ANALYZING A SWITCH SCHEMATIC AND TROUBLESHOOTING

In order to locate trouble in a radio or TV receiver, it is necessary to understand the operation of switches that are employed in the receiver. You cannot know when a switch is a possible cause of the trouble if you do not know what the switch is intended to do and how it is intended to do it. Moreover, it is necessary to understand the switches in order to trace through them while looking for the receiver's trouble. Each receiver's switch circuits have to be analyzed individually because each has circuits different from those of other models. The radio schematic shown in Fig. 21-42 includes two switches — S_1 and S_2 . S_1 is the rotary *function switch*. S_2 is the *phonograph muting switch* (lower left corner of the drawing).

Muting means silencing. The muting switch can be analyzed as follows: S_2 operates to silence the phonograph for the interval of time during which records are being automatically changed. The sound output of the phonograph is shut off from the loudspeaker during this interval. (It would be a loud, annoying scratching sound if it were heard). S_2 is a single-pole single-throw momentary-contact switch with normally closed pressure contacts. While a record is being played, the contacts are held open by the weight of the phonograph tone arm pressing against the moving contact. At the conclusion of a record, when the arm lifts up to return to the rim of the turntable and start a new record, the weight on the moving contact is lifted; the contacts spring closed. With the switch closed, there is a short circuit across the output terminals of the phonograph; there is no output. When the arm comes to rest, at the start of a new record, the contacts again open because the weight of the arm is again upon the moving contact.

What trouble symptoms would lead you to suspect that S_2 is defective? Would you not suspect it if you heard a loud scraping noise coming from the speaker as records changed? And would you not also suspect it if there were no output from the phonograph at all?

In like manner, all switch schematics can be analyzed to learn how switches operate and to learn how they may fail to operate. The rotary switch in Fig. 21-42 can be analyzed in the same way, though it is not as simple as the muting switch. The rotary switch is employed to switch power, $B+$, and signal current. The a-c line current in this receiver is exceptionally low. For this reason, the manufacturer can employ an ordinary rotary switch to switch power. A twelve-contact wafer is employed, although not all contacts are in place. The switch is stopped down to seven positions and the purpose of each position is described in a note on the drawing (center bottom). The switch turns the set on and off; it turns the phonograph motor on and off. It turns off the *station-receiving* part of the radio (it is not needed) when the phonograph is playing. It connects the input of the *sound-reproducing* part of the radio either to the station-receiving part or to the phonograph. At the same time, it grounds out the station-receiving section (while the phonograph plays) or the phonograph (while the radio plays).

S_1 , front, is the deck that turns the radio or phono on and off. One lead from the power plug terminates at clip 11A. In the off (fully counterclockwise) position, this clip is not contacted by a segment. It connects to nothing. Thus, everything is off. In switch position 2, segment W connects clip 11A to clip 10A, and to $-B$; the radio is on. In positions 3 and 4, segment W continues to connect clip 11A to 10A. W does not contact clip 12 (connected to the phone motor) until position 5. In position 5, the phono motor goes on. The radio remains on because clip 11A continues to connect to 10A. However, the station-receiving section goes off because $+B$ (clip 4A) disconnects from V_2 (clip 3A) as segment X breaks connection between 3A and 4A.

Here is how to know that segment X will make contact to clips 3A and 4A in position 4 and break contact in position 5: The switch is shown in position 1. Segment X may be seen to occupy four clips 12, 1, 2, and 3. The right hand end of segment X reaches clip 3 in position 1. It will reach clip 6 in position 4. And, since it occupies four clips, the left-hand end reaches clip 3A;

clips 3A and 4A will be connected. Now, when X reaches clip 7 in position 5, the left end will reach only to clip 4A and not contact 3A; 3A and 4A disconnect in position 5.

You can analyze deck S_1 , rear in a like manner. Try it. Ask yourself which clip connects to the sound-reproducing section. Clip 4B. Which clip connects to the output of the station-receiving section? Clip 1. Which to the output of the phonograph? Clip 7. In which switch position are any

two of these joined? Which two are joined? In which position? In what position are they grounded out? Clip 10A?

S_1 , front, has already been analyzed. It should be possible to say what trouble would result if something went wrong with S_1 front. What trouble would result if contact 4A got bent, and no longer touched segment X? The radio would no longer operate with the switch in a *radio* position.
